Inclusion of Cool Roofs In Nonresidential Title 24 Prescriptive Requirements

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ERRATA (Posted Report)

- Statewide Projected Savings for New Construction (p.18)

TDV NPV energy savings	$22.9M
TDV NPV total savings ~~non-TDV energy savings~~	$27.5M
non-TDV energy savings ~~TDV NPV total savings~~	$18.9M
non-TDV total savings	$23.5M

- Statewide Projected Savings for Roof Replacement (pp. 18-19)

TDV NPV energy savings	$66.4M
TDV NPV total savings ~~non-TDV energy savings~~	$78.9M
non-TDV energy savings ~~TDV NPV total savings~~	$54.8M
non-TDV total savings	$61.8M

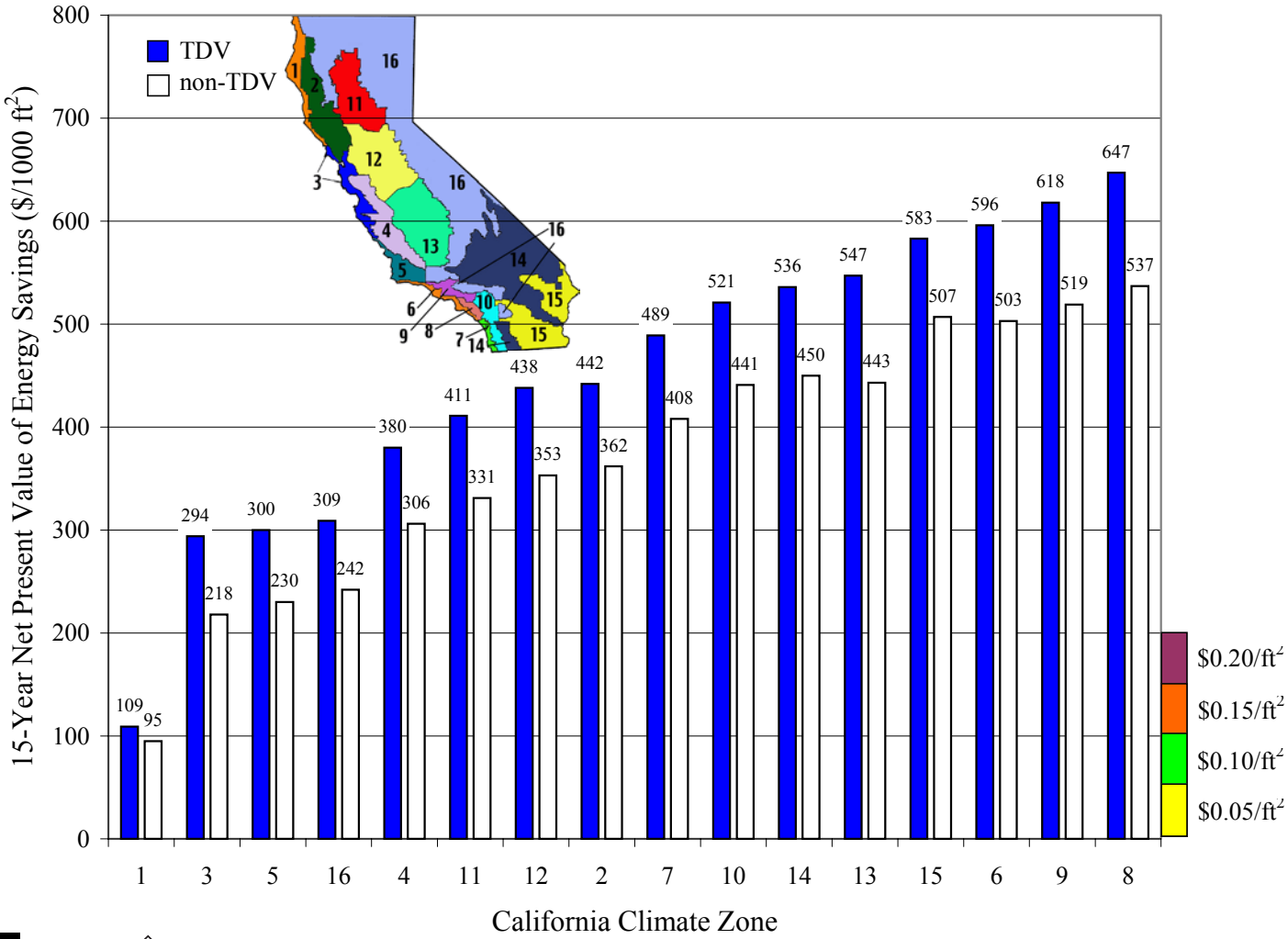
- 15 year NPV energy savings (p. 16)

~~955 to 537 $/1000 ft^2~~ 95 to 537 $/1000 ft^2

Revisions Requested After May 30 Workshop

- Include savings yielded by downsizing air conditioner
  - done
- Simulate SEER12 A/C (rather than EER10)
  - not relevant (SEER12 is for homes, not nonresidential buildings)
  - EER12 was simulated to explore dependence of energy (kWh) and demand (kW) savings on EER; scaled inversely, as expected
  - EER12 results not presented in report, but available
- Estimate savings associated with roof replacement
  - done

15-Year Net Present Value of Energy Savings ($/1000 ft²)



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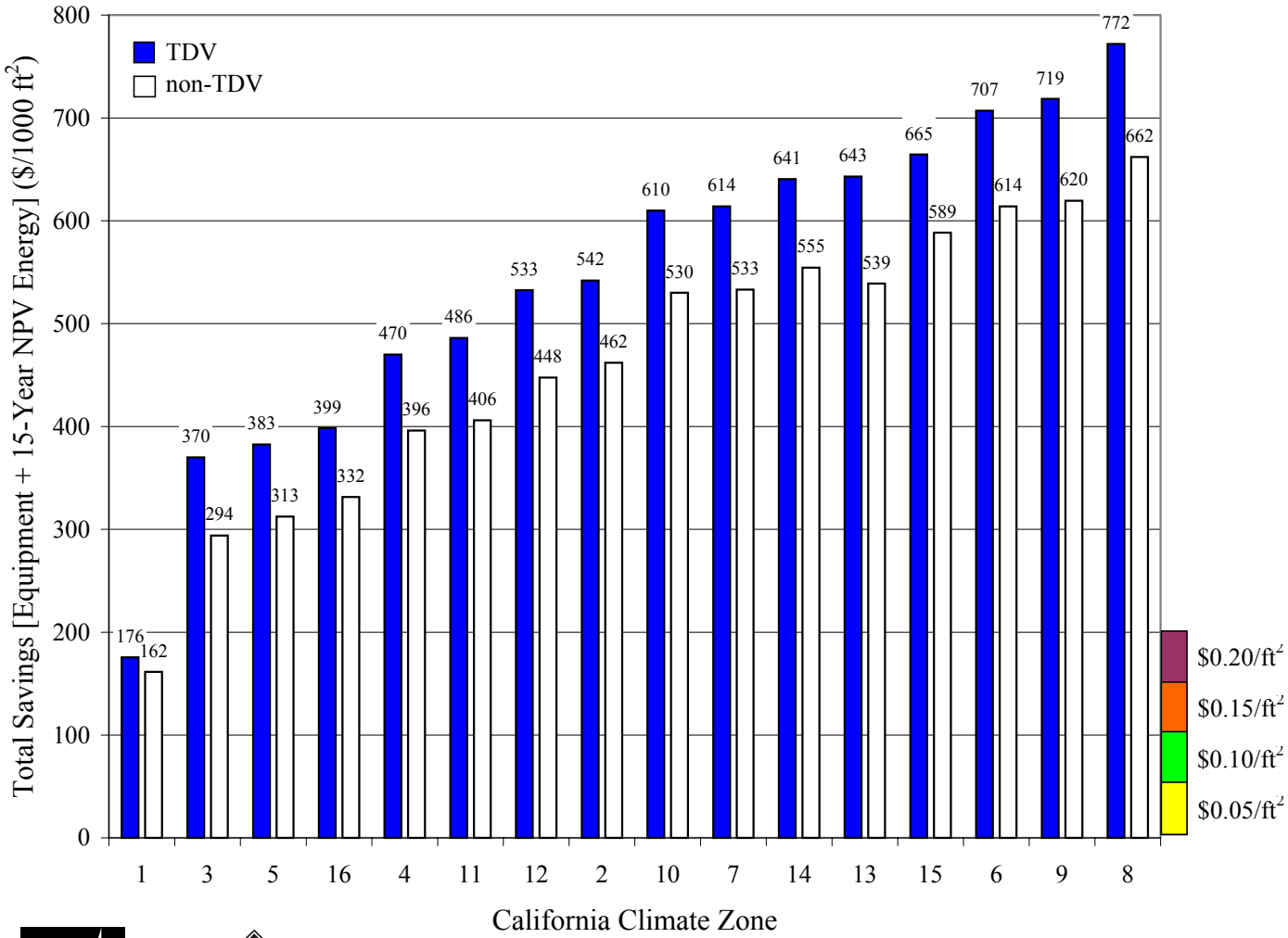
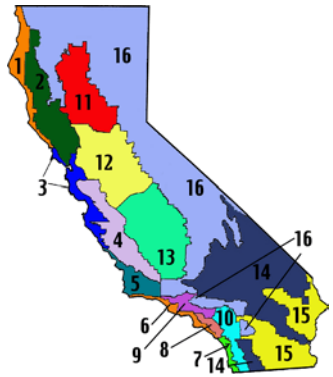
Total Savings (15-Year NPV of Energy + Equipment Downsizing, $/1000 ft²)





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Projected NR New Construction Annual Statewide Savings

- Increase in NR roof area..... **72 Mft^2**
- Increase in low-sloped NR roof area..... **46 Mft^2**
- Electricity savings..... **14.8 GWh**
- Natural gas deficit..... **199 ktherms**
- Source energy savings..... **132 GBTU**
- Peak power demand savings..... **9.2 MW**
- annual equipment savings..... **$4.6M**
- TDV NPV energy savings..... **$22.9M**
- TDV total savings (NPV energy+ equip)..... **$27.5M**
- non-TDV NPV savings..... **$18.9M**
- non-TDV total savings (NPV energy + equip)..... **$23.5M**

Projected Reroofing Annual Statewide Savings

- **Assumption: Reroofing = 2.9 x New Construction**

- Electricity savings..... **43.0 GWh**
- Natural gas deficit..... **577 ktherms**
- Source energy savings..... **383 GBTU**
- Peak power demand savings..... **26.7 MW**
- annual equipment savings..... **$13.3M**
- TDV NPV energy savings..... **$66.4M**
- TDV total savings (NPV energy+ equip)..... **$78.9M**
- non-TDV NPV savings..... **$58.4M**
- non-TDV total savings (NPV energy + equip)..... **$68.1M**

REFERENCE SLIDES

- Please do not include these remaining slides in handouts.

Scope of Proposed Title-24 Change

- Modifies treatment of cool roofs in California's Title-24 standards for non-residential buildings
  - *current*: compliance option only; no prescriptive requirement
  - *proposed*: adds prescriptive requirement for low-sloped roofs
- Prescriptive requirements would not change for
  - non-residential buildings with high-sloped roofs
  - high-rise residential buildings
  - low-rise residential buildings
  - guest rooms in hotel/motel buildings

CoolRoofBenefits

- Roofs stay cool in sun if they have
  - high thermal emittance and high solar reflectance

    OR
  - low thermal emittance and exceptionally high solar reflectance
- Cool roofs can reduce
  - building cooling electricity use
  - peak power demand
  - ambient air temperature

Environmental Impact

- Benefits
  - increased human comfort
  - slowed smog formation
  - mitigation of urban heat islands in summer
  - decreased waste from disposal of roofs
- Penalties
  - slightly higher wintertime heating energy use
  - degraded wintertime urban air quality
  - possible use of water and detergents to clean roofs

Cool Roofs in Existing Title 24 Code

- Prescriptive requirement..... no
- Overall envelope approach..... yes
  - heat gain equation incorporates solar reflectance
- Performance-based compliance..... yes
  - Residential and Nonresidential Alternative Calculation Method
- Cool roofing products defined..... yes
  - clay and concrete tiles: reflectance ≥ 0.40, emittance ≥ 0.75
  - other roofing products: reflectance ≥ 0.70, emittance ≥ 0.75

Code Change Proposal

- Prescriptive Requirements
  - adds requirement for non-residential buildings with low-sloped roofs
- Overall-Envelope and Performance Approach
  - allows compliance credits or penalties
- Changes requirements for cool roofing products
  - qualifies low-emittance products with very high reflectance
  - restricts moderate-reflectance clay and concrete tiles to low-rise residential buildings

Methodology

- Review measure availability and cost
  - technologies, market share
  - manufacturers, distribution
  - availability, cost
  - useful life
- Perform building cost/benefit analysis
  - evaluate measured energy savings
  - use DOE-2.1E to simulate cooling and heating energy use
  - net savings = cooling savings - heating penalty
- Project state-wide savings based on non-residential new construction database

Cool Roofing Product Options

Roofing Product	Cool Variety
ballasted BUR	use white gravel
BUR with smooth asphalt coating	use cementitious or other white coatings
BUR with aluminum coating	use cementitious or other white coatings
single-ply membrane (EPDM, TPO, CSPE, PVC)	choose a white color
modified bitumen (SBS, APP)	use a white coating over the mineral surface
metal roofing (both painted and unpainted)	use a white or cool color paint
roof coatings (dark color, asphalt base)	use a white or cool color coating
concrete tile	use a white or cool color
cement tile (unpainted)	use a white or cool color
red clay tile	use cool red tiles

Sections of Standards To Be Modified

- Section 101 - Definitions And Rules Of Construction
- Section 118(f) - Mandatory Requirements for Cool Roofs
- Section 143(a) - Envelope Component Approach
  - initial emittance $\varepsilon \geq 0.75$, reflectance ≥ 0.70
  - initial emittance $\varepsilon < 0.75$, reflectance $\geq 0.70 + 0.34 \times (0.75 - \varepsilon)$
- Section 143(b) - Overall Envelope Approach
  - Standard Heat Gain Equation
  - Proposed Heat Gain Equation
- Section 149(b) – Alterations To Existing Buildings
- Alternative Calculation Manual (ACM)
  - 2.2.1.4 Absorptance: Proposed Design, Reference Design
  - 2.2.1.5 Surface Emissivity Thermal Emittance
  - 4.3.2.6 Absorptance and Emittance

Cool Roofs in Existing Title 24 Code (Emergency Regulations of January 3, 2001)

- Prescriptive requirement..... no
- Overall envelope approach..... yes
  - heat gain equation incorporates roof solar absortance (1 - reflectance)
  - cool roof absorptance = 0.45, standard roof absorptance = 0.70
- Performance-based compliance..... yes
  - Residential and Nonresidential Alternative Calculation Method (ACM) Approval Manual for performance-based compliance assigns reduced solar absorptance to cool roofs
- Cool roofing products defined..... yes
  - Section 118(f) sets initial solar reflectance and thermal emittance requirements for cool roofs
  - cool clay and concrete tiles: reflectance $\geq$ 0.40, emittance $\geq$ 0.75
  - all other cool roofing products: reflectance $\geq$ 0.70, emittance $\geq$ 0.75

Cost premiums for cool varieties of common low-sloped roofing products

Roofing Product	Cool Variety	Cost Premium ($/ft^2)
ballasted BUR	use white gravel	up to 0.05
BUR with smooth asphalt coating	use cementitious or other white coatings	0.10 to 0.20
BUR with aluminum coating	use cementitious or other white coatings	0.10 to 0.20
single-ply membrane (EPDM, TPO, CSPE, PVC)	choose a white color	0.00 to 0.05
modified bitumen (SBS, APP)	use a white coating over the mineral surface	up to 0.05
metal roofing (both painted and unpainted)	use a white or cool color paint	0.00 to 0.05
roof coatings (dark color, asphalt base)	use a white or cool color coating	0.00 to 0.10
concrete tile	use a white or cool color	0.00 to 0.05
cement tile (unpainted)	use a white or cool color	0.05
red clay tile	use cool red tiles	0.10

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  - Sarah Bretz, formerly of LBNL

Cool options for low-sloped roofs

Noncool Roof Options				Cool Roof Options			
f Type	*Reflectance*	*Emittance*	*Cost ($/ft²)*	*Roof Type*	*Reflectance*	*Emittance*	*Cost ($/ft²)*
lt-up Roof			**1.2 – 2.1**	**Built-up Roof**			**1.2 – 2.15**
dark gravel	0.08 – 0.15	0.80 – 0.90		with white gravel	0.30 – 0.50	0.80 – 0.90	
smooth asphalt ace	0.04 – 0.05	0.85 – 0.95		with gravel and cementitious coating	0.50 – 0.70	0.80 – 0.90	
aluminum coating	0.25 – 0.60	0.20 – 0.50		smooth surface with white roof coating	0.75 – 0.85	0.85 – 0.95	
gle-Ply Membrane			**1.0 – 2.0**	**Single-Ply Membrane**			**1.0 – 2.05**
k (EPDM, CPE, PE, PVC)	0.04 – 0.05	0.85 – 0.95		white (EPDM, CPE, CSPE, PVC)	0.70 – 0.78	0.85 – 0.95	
/ EPDM	0.15 – 0.20	0.85 – 0.95					
dified Bitumen			**1.5 – 1.9**	**Modified Bitumen**			**1.5 – 1.95**
mineral surface sheet (SBS, APP)	0.10 – 0.20	0.85 – 0.95		white coating over a mineral surface (SBS, APP)	0.60 – 0.75	0.85 – 0.95	
al Roof			**1.8 – 3.7**	**Metal Roof**			**1.8 – 3.75**
ainted, corrugated	0.30 – 0.50	0.20 – 0.30		white painted	0.60 – 0.70	0.80 – 0.90	
k-painted, ugated	0.05 – 0.08	0.80 – 0.90					
phalt Shingle			**1.1 – 1.4**	**Asphalt Shingle**			**1.2 – 1.5**
k	0.04 – 0.05	0.80 – 0.90		white	0.25 – 0.27	0.80 – 0.90	
wn	0.05 – 0.09	0.80 – 0.90					
uid Applied ating			**0.5 – 0.7**	**Liquid Applied Coating**			**0.6 – 0.8**
oth black	0.04-0.05	0.85 – 0.95		smooth white	0.70 – 0.85	0.85 – 0.95	
				smooth off-white	0.40 – 0.60	0.85 – 0.95	
				rough white	0.50 – 0.60	0.85 – 0.95	
ncrete Tile			**3 – 4**	**Concrete Tile**			**3 – 4**
	0.10 – 0.12	0.85 – 0.90		white	0.65 – 0.75	0.85 – 0.90	
				with off-white coating	0.65 – 0.75	0.85 – 0.90	
y Tile			**3 – 4**	**Clay Tile**			**3 – 4**
	0.20 – 0.22	0.85 – 0.90					
nent Tile			**3 – 4**	**Cement Tile**			**3 – 4**
ainted	0.18 – 0.22	0.85 – 0.90		white	0.70 – 0.75	0.85 – 0.90	

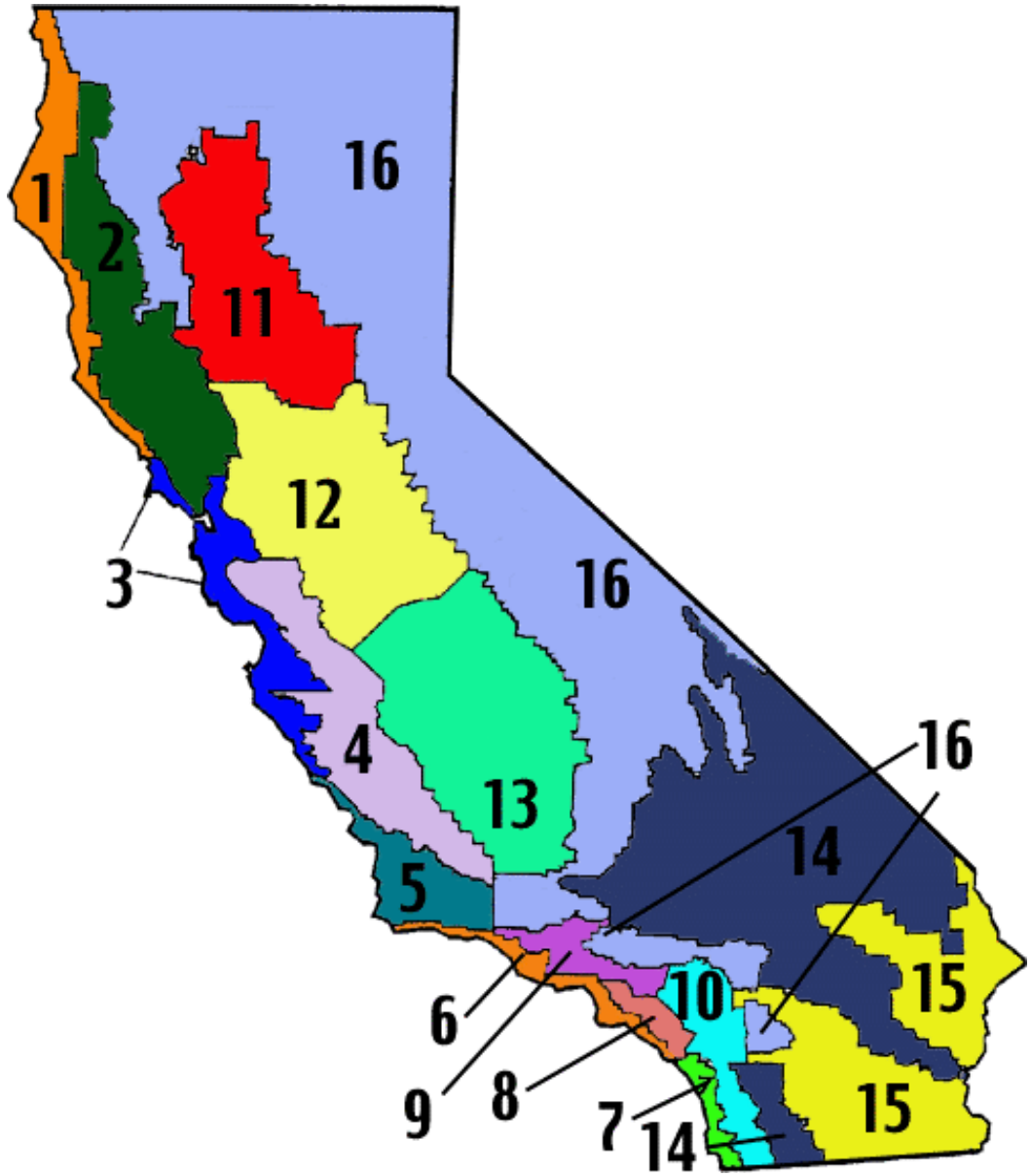
Commercial-building low-sloped roofing technologies and market shares

Technology	Cost[a] ($/ft^2)	PACIFIC[b] New Sales	PACIFIC[b] Retrofit Sales	WESTERN[c] Sales	WESTERN[c] Area[d]
Built-up Roof (BUR)	**1.7**	**46%**	**52%**	**31%**	**27%**
Modified Bitumen	**1.7**	**10%**	**15%**	**30%**	**26%**
Single-Ply Membrane	**1.5**	**18%**	**16%**	**23%**	**22%**
Metal	**2.7**	**2.2%**	**1.7%**	**5.2%**	**2.8%**
Asphalt Shingle	**1.3**	**5.8%**	**2.5%**	**3.6%**	**4.2%**
Tile	**3.5**	**2.5%**	**3.9%**	**0.3%**	**0.1%**
Polyure-thane Foam (SPF)	**0.7**	**0.4%**	**6.3%**	**2.5%**	**5.2%**
Liquid Applied Coatings	**0.4**	**3.2%**	**3.3%**	**2.5%**	**9.2%**
Other	**1**			**2.1%**	**3.1%**

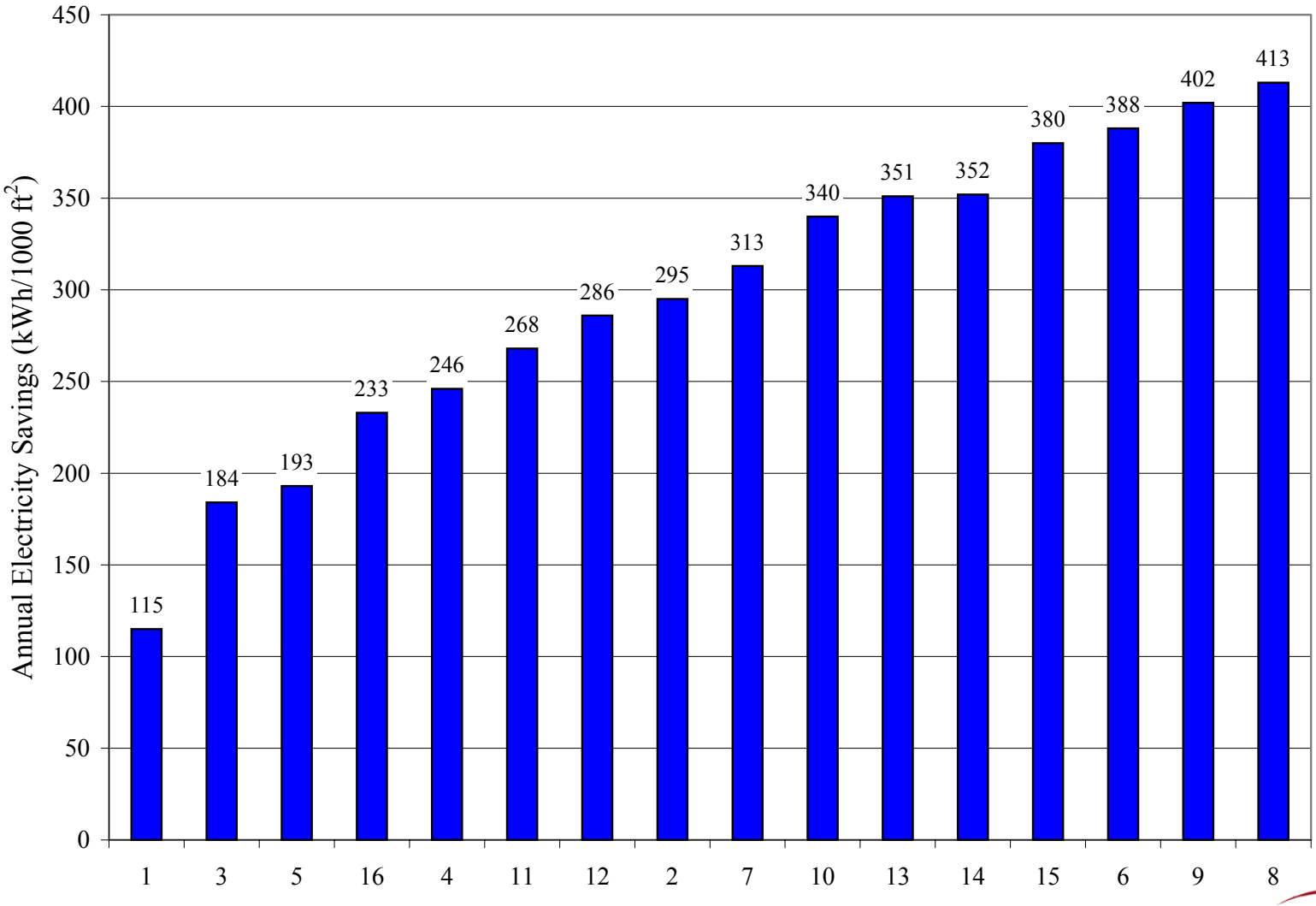
Life Expectancies Of Roof Materials

Roofing material	Life expectancy (yr)
wood shingles and shakes	15 to 30
tile[a]	50
slate[b]	50 to 100
sheet metal[c]	20 to 50+
BUR/asphalt[d]	12 to 25
BUR/coat and tar[d]	12 to 30
single-ply modified bitumen	10 to 20
single-ply thermoplastic	10 to 20
single-ply thermoset	10 to 20
asphalt shingle	15 to 30

California
Climate Zones



Annual Electricity Savings (kWh/1000 ft²)



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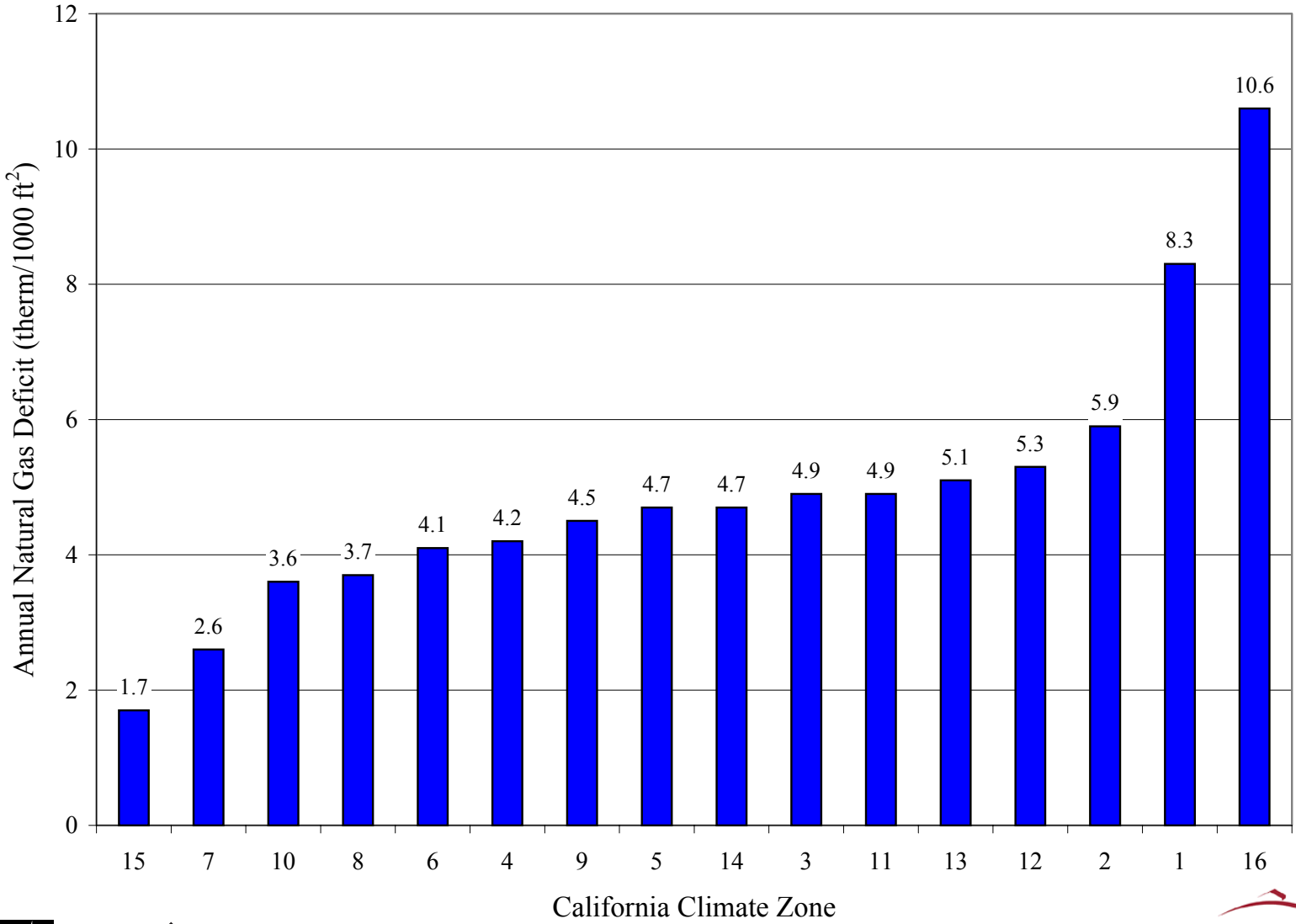
Annual Natural Gas Deficit (therms/1000 ft²)



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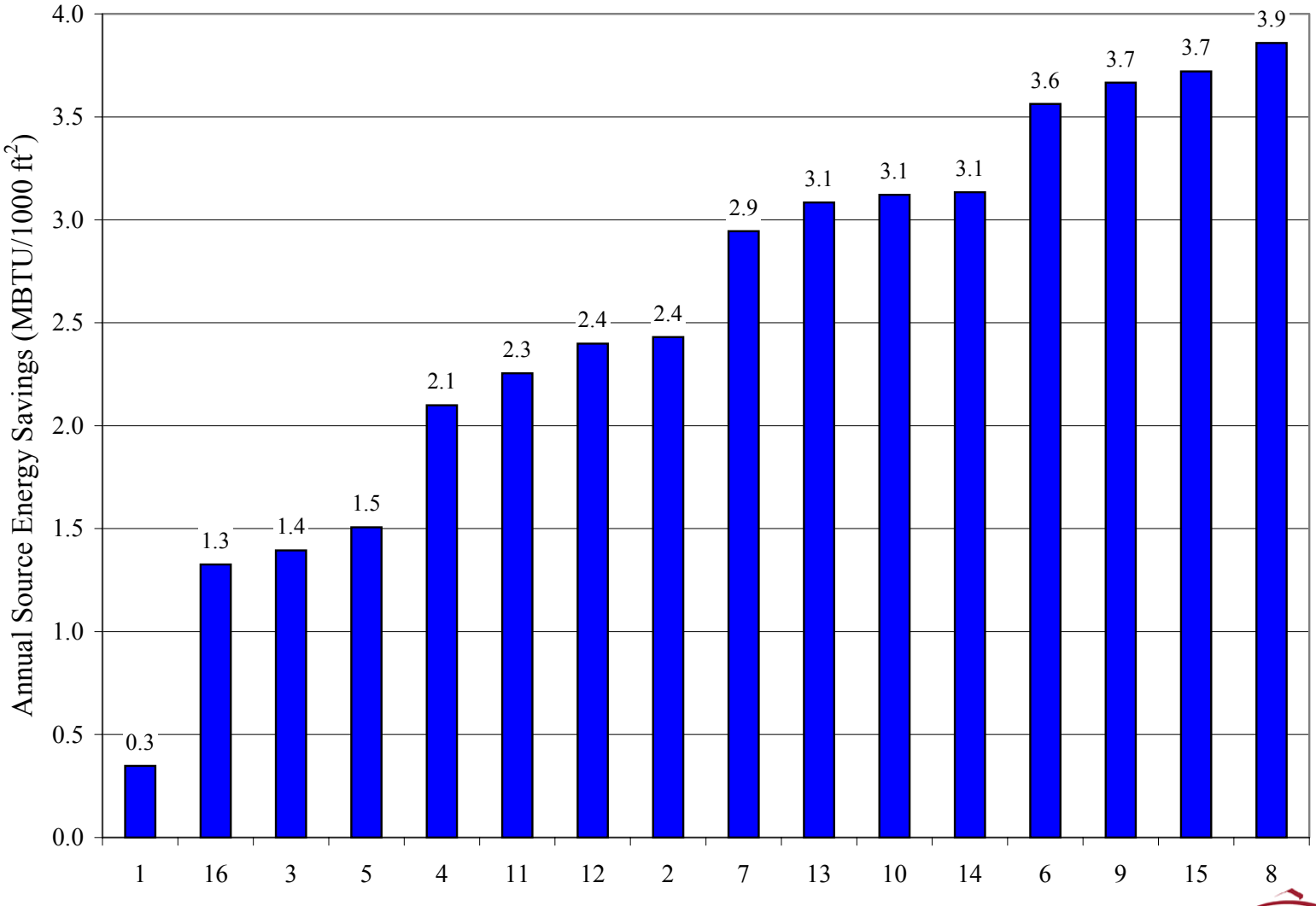
Annual Source Energy Savings (MBTU/1000 ft²)



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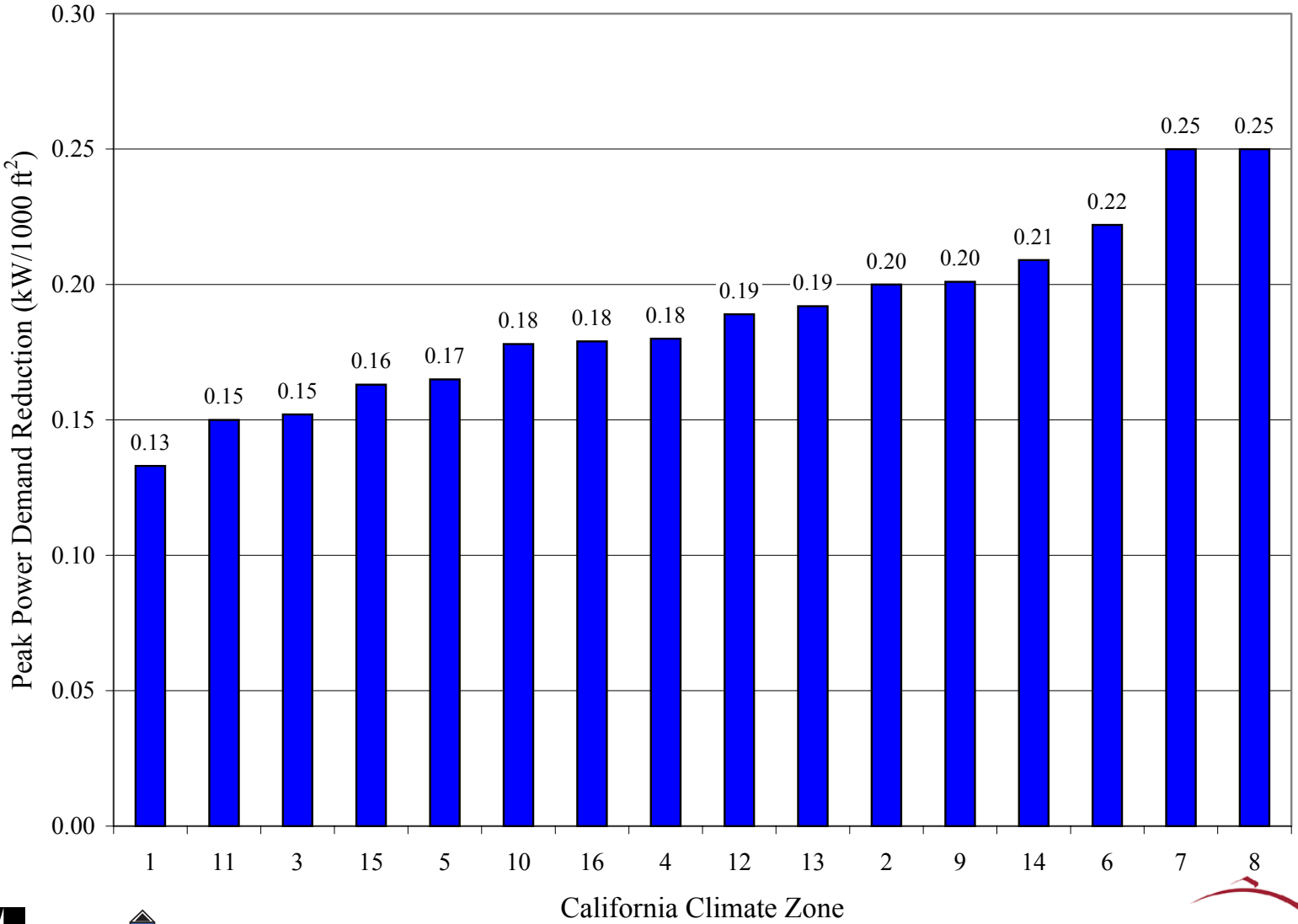
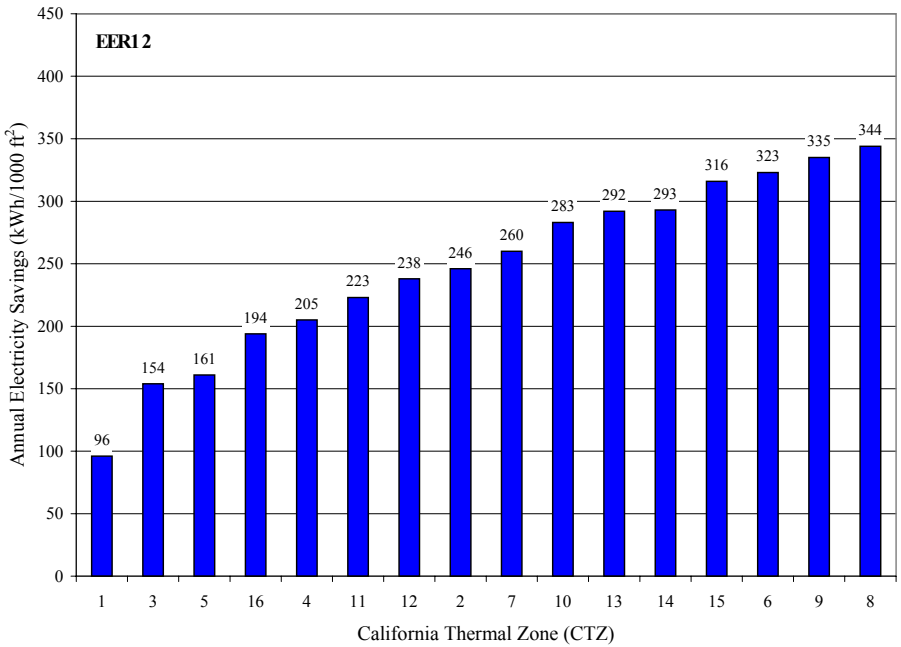
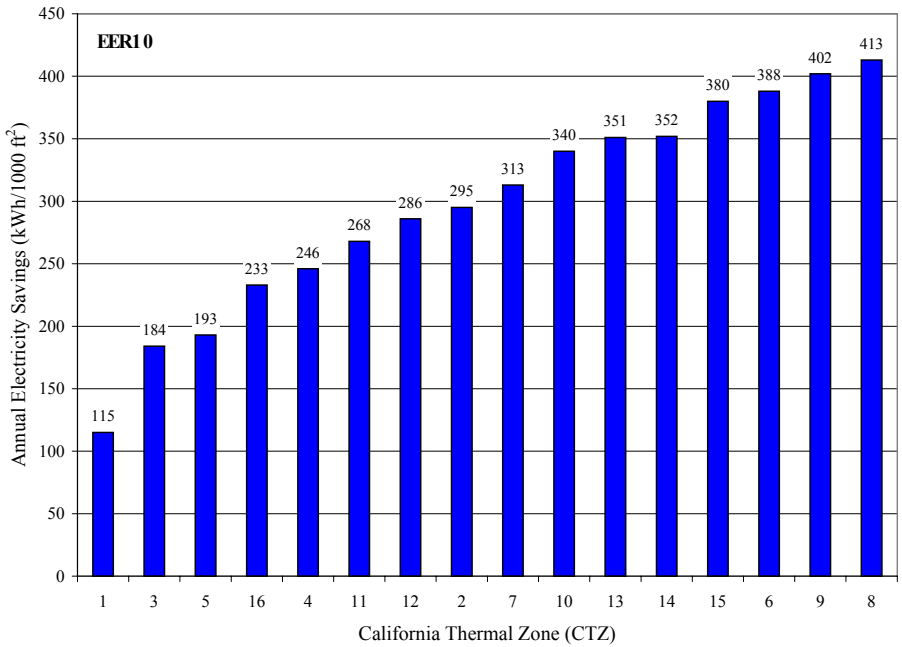
Peak Electrical Demand Reduction (kW/1000 ft²)

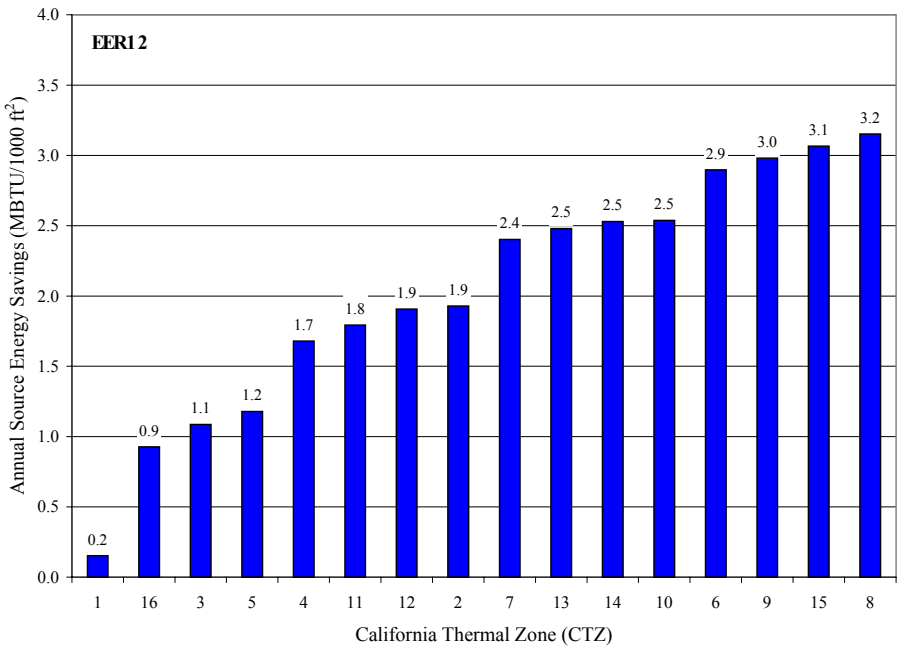


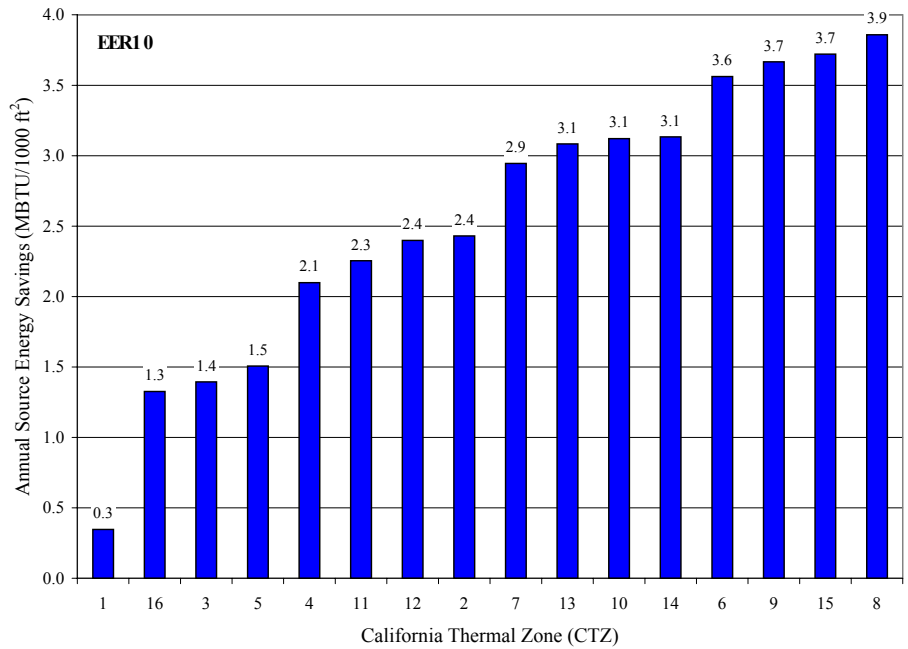
Annual Electricity Savings (kWh/1000 ft²): EER12 vs. EER10



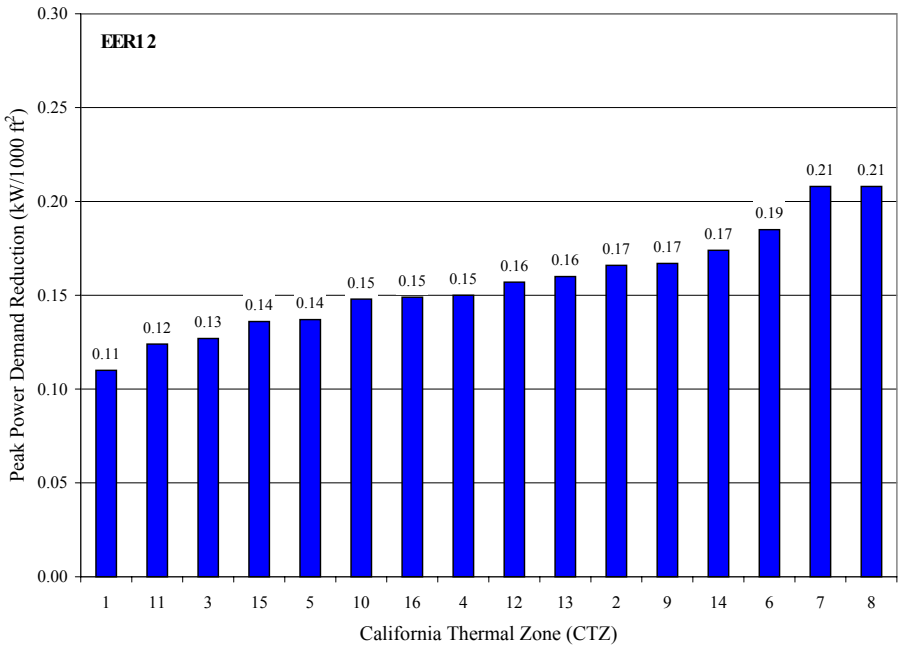


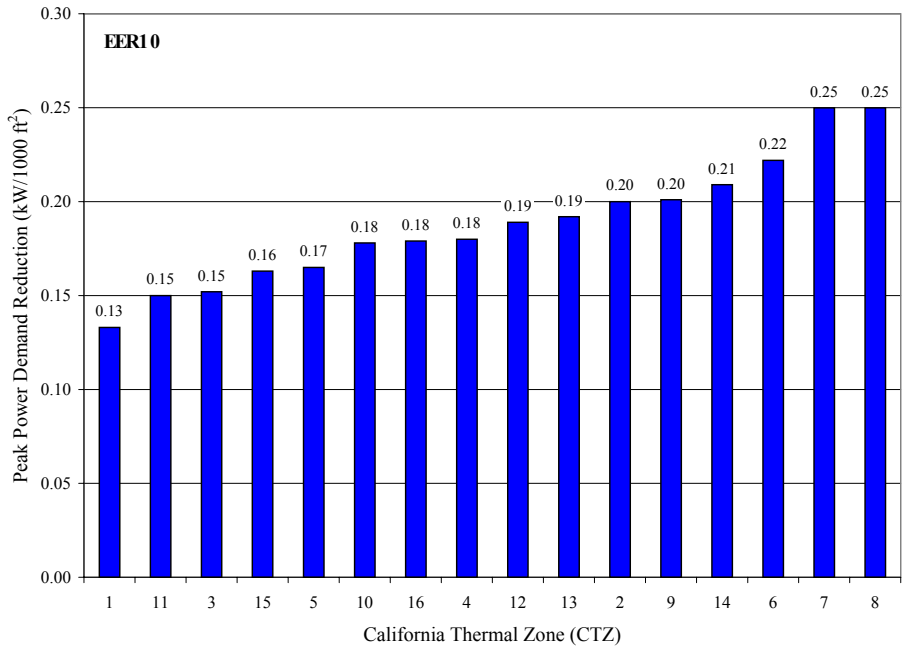
Annual Source Energy Savings (MBTU/1000 ft²): EER 12 vs. EER 10



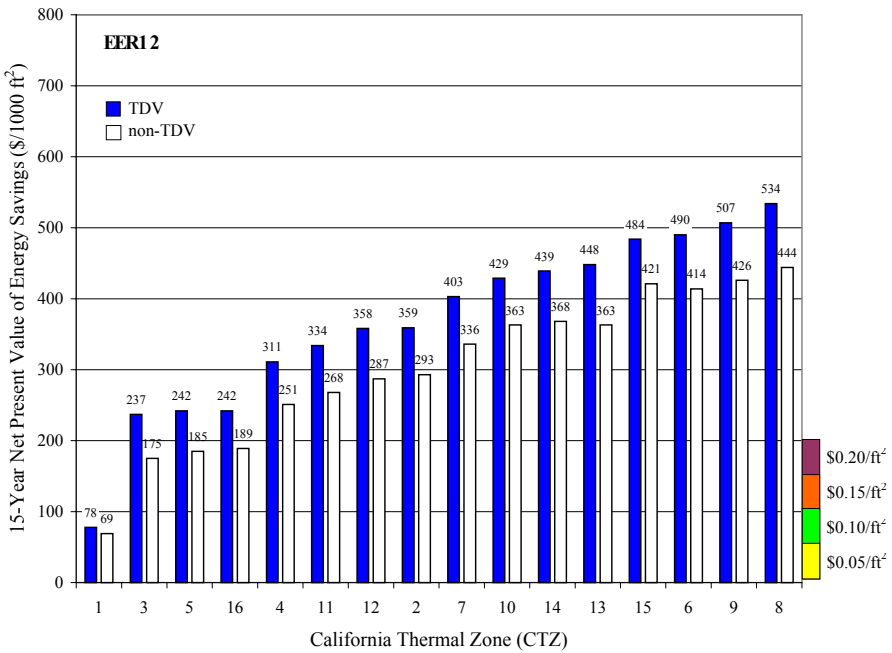


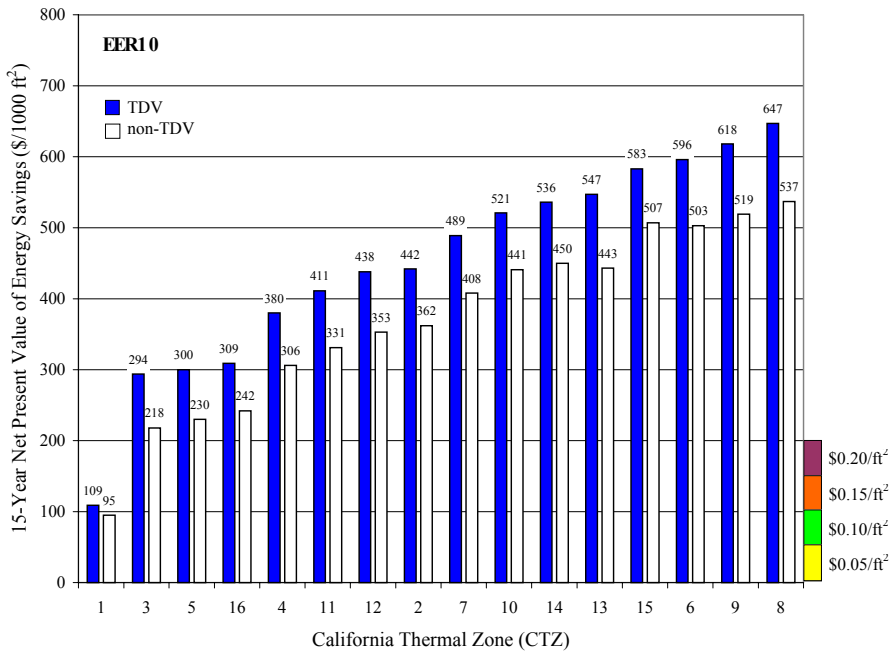
Peak Power Demand Savings (kW/1000 ft²): EER12 vs. EER10





NPV Energy Savings ($/1000 ft²): EER12 vs. EER10





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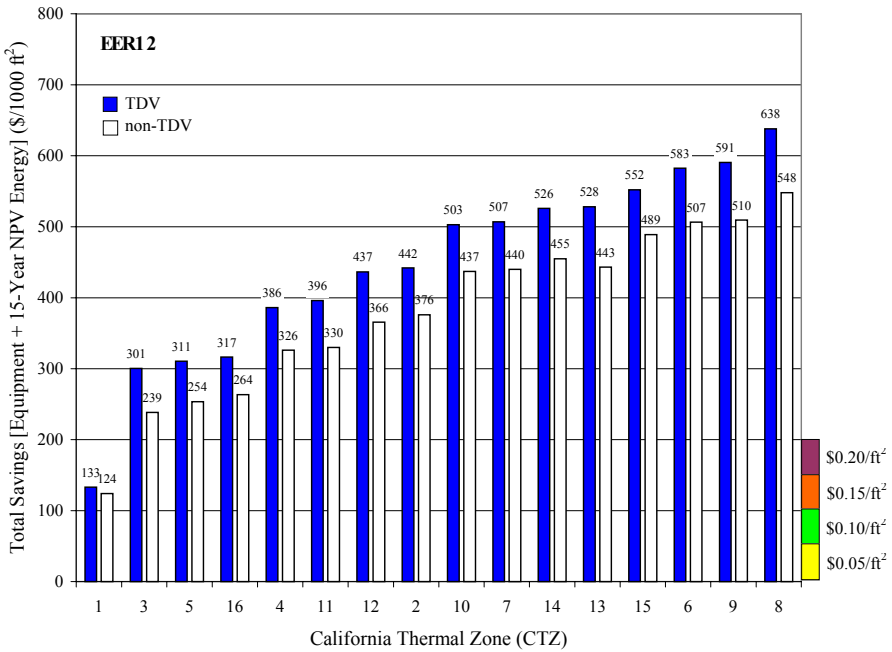
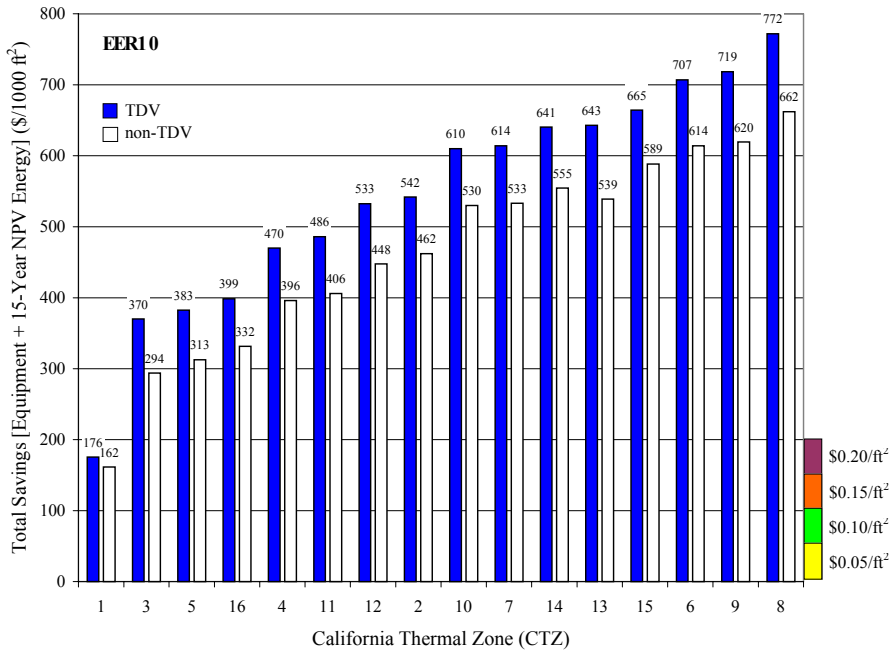
Total Savings (NPV Energy + Equip, $/1000 ft²): EER12 vs. EER10





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Section 143 – (a) Envelope Component Approach

For nonresidential buildings with low-sloped roofs (except high-rise residential buildings and guest rooms of hotel/ motel buildings), roofs that have an initial thermal emittance not less than 0.75 shall have a minimum initial solar reflectance of 0.70. Low-sloped exterior roofs that have an initial thermal emittance $\varepsilon_{\text{initial}}$ less than 0.75, including but not limited to those with metallic surfaces, shall have a minimum initial solar reflectance of $0.70 + 0.34\left(0.75 - \varepsilon_{\text{initial}}\right)$.

Section 143 – (b)0 verall Envelope Approach: Standard Heat Gain EQ.

$$+\sum_{i=1}^{nR}\left(WF_{Ri}\times A_{Ri}\times U_{Ri_{std}}\times \alpha_{Ri_{std}}\left[1-\left(0.2+0.7\left[\rho_{Ri_{std}}-0.2\right]\right)\right]\right)\times SF$$

~~$\alpha_{Ri_{std}}$ = A standard roof absorptivity of 0.70 for the corresponding A_{Ri}~~

$\rho_{Ri_{std}}$ = For low-sloped roofs on nonresidential buildings (excluding high-rise residential buildings and guest rooms in hotel/ motel buildings), a standard initial roof reflectance of 0.70 for the corresponding A_{Ri}; for other than low-sloped roofs on nonresidential buildings, for high rise residential buildings, and for guest rooms in hotel/ motel buildings, a standard roof reflectance of 0.30 for the corresponding A_{Ri}.

Section 143 – (b) Overall Envelope Approach: Proposed Heat Gain EQ.

$$+\sum_{i=1}^{nR}\left(WF_{Ri}\times A_{Ri}\times U_{Ri_{prop}}\times \sout{\alpha_{Ri_{prop}}}\underline{\left[1-\left(0.2+0.7\left[\rho_{Ri_{prop}}-0.2\right]\right)\right]}\right)\times SF$$

~~$\alpha_{Rj_{prop}}$ = The applicable roof absorptivity for the corresponding A_{Rj}. An absorptivity of 0.45 for cool roofs (as defined in Section 118). An absorptivity of 0.7 for all other roofs.~~

$\rho_{Rj_{prop}}$ = the proposed initial reflectance for the corresponding A_{Rj}. If no CRRC-certified value is available, the proposed reflectance will use the default value of 0.10 for low-sloped roofs on nonresidential buildings (excluding high-rise residential buildings and guest rooms in hotel/motel buildings), or 0.30 for other than low-sloped roofs on nonresidential buildings, for high-rise residential buildings, and for guest rooms in hotel/motel buildings.

Proposed ACM Language
2.2.1.4 Absorptance: Proposed Design

For nonresidential buildings with low-sloped roofs, the proposed design must receive user input for initial absorptance (α_{init}; absorptance = 1 - reflectance). The ACM must calculate the corresponding aged value α_{prop} from the following equation:

$$\alpha_{prop} = 0.8 + 0.7\ (\alpha_{init} - 0.8)$$

where α_{init} is the initial absorptance of the product either as rated by the CRRC or one of the defaults specified below.

Proposed ACM Language
2.2.1.4 Absorptance: Reference Design

For the reference method for nonresidential buildings with low-sloped roofs (excluding high-rise residential buildings and guest rooms in hotel/motel buildings) the roof absorptance (1 – reflectance) shall be modeled at 0.30 (reflectance 0.70). For the reference method for nonresidential buildings with other than low-sloped roofs, for high-rise residential buildings, and for guest rooms in hotel/motel buildings, the roof absorptance shall be modeled at 0.70 (reflectance 0.30).

The ACM must calculate the corresponding aged value α_{ref} from the following equation.

$$\alpha_{ref} = 0.8 + 0.7\ (\alpha_{std} - 0.8)$$

where α_{std} is 0.30 for nonresidential buildings with low-sloped roofs or 0.70 for other nonresidential buildings, high-rise residential buildings and guest rooms in hotel/motel buildings